Minimal mindfulness of the world as an active control for a full mindfulness of mental states intervention: A Registered Report and Pilot study

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**Keywords:** Mindfulness, Meditation, Metacognition, Decentring, Placebo

NOTE: The standard text in this chapter is the Stage 1 with in principle acceptance:

Lovell, M., & Dienes, Z. (2022). Minimal mindfulness of the world as an active control for a full mindfulness of mental states intervention: A Registered Report and Pilot study, in principle acceptance of version 4 by *Peer Community in Registered Reports*. https://osf.io/tx54k Recommendation: <https://rr.peercommunityin.org/articles/rec?id=45>

Tracked changes text is the in-progress Stage 2. The stopping rule has not been reached, so interim results and conclusions are presented here.

Summary

Mindfulness is a continual renewal of non-elaborative attention on an object of focus, without clinging or aversion, and with equanimity. As this requires the capacity to monitor and control the extent to which one is on task, it is a metacognitive exercise. Mindfulness is especially metacognitive when directed towards mental states themselves, which is largely how the practice was conceived in the original Buddhist scriptures. Alternatively, mindfulness could be directed towards the world around oneself in a less metacognitive fashion. Notably, whilst mindfulness of the world is directed towards the referents of sensory states (e.g., “the sky is blue”), mindfulness of mental states includes a higher-order awareness of the experience of a sensory state as a mental state in and of itself (e.g., “I see the sky is blue”) – as a sensation.

We aim to test the centrality of metacognition in mindfulness practice by contrasting a full Mindfulness of Mental States intervention against a minimal Mindfulness of the World intervention, to act as a potential active control for non-specific effects, alongside a Waitlist control. Survey measures of mindfulness directed at the world and mental states separately, mental health measures, and participant expectations for each of these outcomes, will be administered. Bayesian contrasts of the group by time interaction will be the primary analysis used to test, for the first time, the effects of mindfulness against a true active control (if it should turn out to be one). Pilot data presented in the first section below show some promising initial results. Between the Mental States and World focused conditions, evidence in the hypothesised direction was discovered on the Observe and Acting with Awareness facets of the 24-item FFMQ-sf (other facets were insensitive), on the PHQ-4 anxiety subscale, and on the RRS.

# Introduction

Amongst the recent explosion of scientific, clinical, and public interest in mindfulness, there are concerns as to the lack of adequate control groups and imprecise and inconsistent definitions in the scientific literature on the subject (1). Metacognition - the monitoring and control of mental processes - is a component of Buddhist renderings of mindfulness (2,3), and it has become important in many scientific theories (4–6), although this skill may be relatively under-developed in those components of modern mindfulness interventions that focus on awareness of ‘the present moment’ via sensory states. The contrast between practices that more or less fully aim to cultivate metacognitive skills opens up an opportunity to test metacognitive theories of mindfulness while controlling for other specific and non-specific effects of the practice.

In relation to Buddhist texts, ‘mindfulness’ is a translation of ‘sati’, which can be understood as an awareness of mental states as content bearing vehicles happening now, to be selected, labelled, or let go of according to task requirements, without clinging or craving (3,7,8). By objectifying the constituents of the mind, the subject thus ceases to be viewed as such, and is ‘dissolved’. This loss of ‘self-ness’ by objectification of experience mirrors decentring theories of mindfulness, wherein mental states are understood as separate from any outside phenomena they may represent, and less attached to a cognitive set of ‘self-ness’, consisting of concepts like ‘I’, ‘mine’, ‘me’, and ‘myself’ (5; see also ‘reperceiving’ in 9). Thus, the thought “I am annoyed” can become “there is the feeling of annoyance”, with its content being taken as a property of a representational vehicle, and therefore less ‘at face value’ and 'true', transforming the subjective experience itself. Bernstein et al. (10,11) argue that mindfulness is one term amongst many in the cognition literature which describe such metacognitive ‘decentring’ - “The capacity to shift experiential perspective—from within one’s subjective experience onto that experience” (10, p.599).

Mindfulness thus aims to train a metacognitive transformation in how we perceive and respond to mental states. Several survey measures have recorded mindfulness induced increases in decentring (5,12; *Or:* 13–16; *Or:* 17,18). Other lines of research support the theory that mindfulness actively trains metacognitive skills more generally and in different domains. Intentional binding denotes the compression of estimates of the timing of an action and resultant outcome during a consciously intended action, where either the subjective time of the action shifts towards the objective time of the outcome (action binding), or vice versa (outcome binding) (19,20, *but see:* 21). Attending to one’s inner decision-making processes, as in mindfulness, leads to earlier estimates of action timing (22), and experienced Buddhist mindfulness meditators may have greater outcome binding than non-meditators, and thus a greater awareness of intentions (23). Negative correlations between hypnosis and mindfulness scales (24–26) are explained by theories that see hypnotic suggestibility as the result ofinaccurate metacognition about one’s intentions to respond (27,28). Phrasing hypnotic suggestions in a Buddhist friendly manner to raise expectations (although not successfully equalise them) does little to alter meditator’s low hypnotic response rate (*cited in:* 29). As one might expect, hypnotisability has a negative relationship to action timing estimates, whilst meditators were significantly quicker and more consistent than averagely hypnotisable individuals (25). Finally, neurological evidence concurs, as several areas of the pre-frontal cortex appear to be involved in both metacognition (30,31) and mindfulness (*left dorsolateral:* 32–34; *medial:* 35,36; *ventrolateral:* 37), and likewise in the anterior cingulate cortex (38,39).

The clinical utility of the above is that this re-evaluation of experience in effect buffers against the self-reinforcing effect of negatively valenced cognitions as they are viewed as transient, non-factual mental states (5,40–42). Because of the apparent positive effects of mindfulness on mental health, it is offered by health services worldwide as a treatment for, notably, stress, anxiety, and depression. In the psychological literature, mindfulness is primarily conceptualised as a therapeutic practice, and the effectiveness of an intervention judged by measures of the aforementioned mental health issues (43,44). The link between metacognition and psychopathology extends beyond mindfulness - Adrian Wells has built up an extensive research enterprise which claims that metacognitive failings are a key factor in all psychopathologies (45). Therefore, according to Wells, metacognitive training is an active component of many effective therapies, including mindfulness (41,46). It is of no small practical importance, then, to understand and perhaps develop the potential contributions of the metacognitive mechanisms involved in mindfulness, and their relation to its effects on mental health.

Notably, a set definition of sati is not constitutive of the practice of what we might call ‘mindfulness meditation’ – the modern use of which refers to a broad, sometimes contradictory (e.g. 47), class of concepts and exercises scattered throughout the Buddhist canons and wider commentaries. An early account of mindfulness practice central to both many Buddhist meditation practices (3) and the current clinical approach (48–50), can be found in the Satipatthana Sutta. At its core, this practice instructs a continual renewal of non-elaborative attention on an object of focus. As this requires the capacity to monitor and control the extent to which one is on task, it is a metacognitive exercise (for a related but different approach to meditation see 51). Furthermore, one is to be ‘non-clinging’ (letting mental states go, holding in mind only that which is relevant to the practice), and equanimous (maintaining a calm composure in the face of both positive and negative mental states). These are metacognitive skills in that they require seeing mental states in terms of content carried by vehicles, accompanied by executive evaluation and management.

The four groupings of experiential phenomena to which this mindset is directed, the four Satipatthanas, are the body, feelings, the mind, and mental states relevant to flourishing (dhamma, c.f. 3). The last three of these explicitly concern types of mental states, and so mindfulness involves metacognition in this sense also. Even when the body (e.g. the breath) is used as the persisting target, the Anapanasati Sutta (MN iii 78; 52) extends mindfulness of breathing to cover all four Satipatthanas (3, pp. 21-22), developing an awareness of sensory states as sensations. Correspondingly, Dienes et al., (29) understand mindfulness using Higher Order Thought (HOT; 53) theory to distinguish mental states with content simply about the world (e.g. seeing that “The sky is blue”), from second-order states which refer to those first-order states (e.g. being aware that “I see the sky is blue”), which in turn can be the subject of yet higher third-order states (e.g. being aware that “I am aware that I am aware the sky is blue”). Similarly, mindfulness may target the external world itself, or, as is more typical in Buddhism, mental states. Appealingly, others have pointed to similarities between HOT theory and Buddhist descriptions of consciousness (54–56), although one need not subscribe to HOT theory as a theory of consciousness to realise the distinctions it makes are useful.

With that being said, continually redirecting attention, when distracted, to the world around oneself (including one’s own body as a non-mental object), whilst avoiding elaborative thinking, is in-line with many mindfulness practices. Even in the Buddhist literature, The Vimuttimagga (second century) instructs practitioners to focus on earth or soil around them as an external visual object until they can form a mental image of it (57), whilst a passage in the Majjhima Nikāya instructs: “Not perceiving form internally, someone sees visions externally, blue, with blue color, blue hue, and blue tint” (58, p. 639). We will use such an external, world-focused variant of mindfulness to actively control, to some degree, for the metacognitive faculty which is emphasized in the experimental condition. As participants may accept such practices to be genuine mindfulness - as indeed they are - we avoid deceiving participants, whilst (potentially) controlling for non-specific factors like expectations.

As current theoretical work does not distinguish between mindfulness directed to the world as such versus to mental states, interventions may emphasise the former over the latter. Breath and body-scan meditations, hatha yoga, and mindful eating take up most of MBSR (59) courses, and are not necessarily done so in a mental states rather than world-focused manner, although in MBCT in particular focusing on thoughts and emotions is a central part of the mindfulness training (60,61). That is not to say there is no clinical utility in a world-focused meditation - a non-metacognitive focus may provide respite from difficult mental states like extreme anxiety. As such, we will compare this intervention to a Waitlist control. Nevertheless, as mindfulness of the world involves less metacognitive training than a full mindfulness intervention, the Mindfulness of World intervention may constitute a minimal mindfulness intervention.

Mindfulness of the World is therefore a possible placebo control for a mental states focused condition, insofar as metacognition is theorised to be a key mindfulness component. This faculty is not cleanly isolated from the World condition - an awareness of whether one is being aware of the object of focus or not requires metacognition, as does becoming aware of any disruptive thoughts. Still, the extent of metacognitive training should be greater when mindfulness is primarily directed towards mental states rather than the world. Moreover, mindfulness is conceptualised exclusively in our mental states intervention to include metacognitive skills such as non-suppression, non-clinging, and equanimity.

This design is an improvement on the abundance of Waitlist-controlled trials in the literature (43,62). Of those studies that do use active controls, the majority are therapies against which available measures struggle to differentiate the active components of the mindfulness condition (63–67); perhaps as these therapies often contain mindfulness components (68,40,69). Some studies have employed a 'sham-mediation' intervention as a placebo condition (70; *similar in:* 71), which asks participants to just sit and ‘meditate’ with minimal instructions as to how. Specifically, instructions are to “Just relax, reduce any expectations” and “take a couple of deep breathes, in through the nose out through the nose as we sit here in meditation” and “stillness” (72). Similarities to Zen Shikantaza ‘just sitting’ meditation (73–75) aside, just asking participants to breathe may lead to a focus on the breath. Whilst initially appearing inactive compared to mindfulness (70,76), later studies have not recorded a significant difference between "sham" mindfulness and regular mindfulness conditions (72,77). It should also be noted that, although these studies presented both their interventions as mindfulness, expectations of outcome variables were not necessarily equalised - different meditation exercises may confer different presumptions about their effects. For example, participants may assume that attending to negative affect can be distressing (78).

Likewise, although not technically a placebo as neither condition was presented as mindfulness, the ‘mind-wandering’ intervention of (79–84) was deployed to account for all non-specific effects. This intervention asks participants to ‘‘simply think about whatever comes to mind. Let your mind wander freely without trying to focus on anything in particular’’ (85). The original intent of this intervention was not mind-wandering, but ‘unfocused attention’ (85,86), a name that highlights its similarity to the ‘effortlessness’ and ‘lack of grasping or focus’ of Open Monitoring meditation (87,88). Allowing thoughts to come and go is common to mindfulness interventions and definitions (89–91; *headspace:* 77 [supplementary]) - for some, it is actually stopping the ebb and flow of thoughts that is inconsistent with mindfulness practice. Trying to mind-wander may counter-intuitively bring attention and a metacognitive distance to such mental activity, despite true mind-wandering consisting of a “task unrelated thought, that is, engaging in cognition unrelated to what one is supposed to be doing in the here and now” (92, p.389, c.f. 93). If conditions contained equivalent amounts of mindfulness but differed only in expectations, the contrast between conditions would have been actually reflective of the placebo effect and not of mindfulness. Where these attempts at making placebo-esque mindfulness control interventions have essentially asked participants to not focus, we ask participants focus on things which aren’t mental states.

Similar to our own study, Schmidt et al. (94) split MBSR into either body or mental states focused material. Schmidt relied on a measure of metacognition termed metacognitive efficiency - the correspondence between objectively correct decision-making and subjective confidence in those decisions (see Methods). Whilst one’s accuracy on a two-alternate forced choice task reflects the function of sensory organs and low-level sensory processing, the ability to assess one’s own task performance (i.e., confidence) is used as an index of one’s ability to consciously discern the quality of that perceptual information. Rather than use a simple correlation of accuracy and performance, the meta-d’ statistic (95) relies on the probabilities of high or low confidence and correct or incorrect decisions to estimate the correspondence between these two metrics in a way unbiased by each participants’ idiosyncratic use of the confidence scale (‘metacognitive sensitivity’). Meta-d’ can then divided by a measure of participant accuracy (i.e., meta-d’/d’) to give us a participant’s ‘metacognitive efficiency’ – their metacognitive sensitivity for a given level of accuracy.

Schmidt et al. (94) recorded a significant time-group interaction, which was further analysed to reveal that the mental states condition did not produce a significant change in metacognitive efficiency, although a decrease of such abilities in the body focused condition suggests the latter intervention exercised skills other than metacognition. Although using an 8-week 30 mins+ per-day MBSR course, numbers were small (N = 27; compare e.g. N = 104 for a just significant increase after a 10-day course compared to Waitlist in Cavanagh et al. (96), although this course was unsupported and online), with an only just significant interaction. Without a Waitlist control and recorded expectations, expectation effects cannot be ruled out. Other papers have empirically separated different contemplative practices but not necessarily different types of mindfulness per se (see e.g. 97). Precursors to the Schmidt et al. (94) study did find metacognitive efficiency to be malleable through both feedback (98) and mindfulness (99). Notably, Carpenter et al. (98) found that improvements in experimental groups trained on metacognitive performance on either perceptual or memory tasks transferred to the other untrained domain. Domain generality in metacognitive efficiency has also been demonstrated by significant correlations between tasks measuring this construct (100). The current study will build on these findings by examining if visual metacognitive *sensitivity* (adjusted for d’, see below) improves in our Mindfulness of Mental States intervention.

# Pilot Study

For brevity, we present an abridged write-up of the pilot study here. A full write up of the pilot study, along with data, analysis code, and materials can be found in the online supplementary.

## Methods

The pilot study consisted of a 10-minute meditation each day for 10 days, with a 3-day limit between practices before a participant was assumed to have withdrawn from the study. Pre-test surveys were conducted over video call, after which participant information was passed to a second experimenter who randomly assigned conditions by pulling the condition names out of a hat. This second experimenter handled daily standardised emails (which indicated what meditation to do and asked a question about the experience) and alerted the first experimenter (who was condition-blind) when the participant was ready for their second survey video call.

Mindfulness of World and Mental States groups were given access to a condition-relevant website which featured information about mindfulness, a prompt to do mindfulness during daily activities, and the guided meditation audio. Separate instructions were emailed each day, with a response to questions probing intervention adherence required for the next day's email to be sent. Although the audio file remained consistent throughout each intervention, emailed instructions differed each day. The Mindfulness of the World condition (*N*=40) audio instructed participants to attend to their breath and body, whilst email instructions asked participants to become aware of the world around them in a radius that became progressively bigger each day. The Mindfulness of Mental States condition (*N*=47) audio started on the breath and moved on to an awareness of passing thoughts and sensations in a detached manner as “just thoughts”, whilst emails instructed participants to focus on different mental states each day including: intentions, feeling tone (positive, negative, or neutral), desires, emotions, the beginning, end, and transition between states, and finally an open-monitoring style. Participants in the waitlist control (*N*=35) were given access to the post-test survey and one of the conditions after 10 working days.

We hypothesised superior performance on a mindfulness questionnaire (FFMQ) from pre- to post-test in a Mindfulness of Mental States condition compared to a Mindfulness of the World condition - the latter of which was in turn hypothesised to perform superior to a Waitlist condition. We also reasoned that, if Mindfulness of the World was shown to have equivalent FFMQ to waitlist and inferior performance to the Mental States condition, this would indicate it could be a useful active control condition. If Mindfulness of Mental States and Mindfulness of World had equivalent expectations for change on outcome variables (depression, anxiety), the latter would show itself to be a good active control condition. Data was collected over several years by student researchers. A final dataset contained 94 participants (52 Female; Ages 18-50, *M*=24, *SD*=5.79). Missing data was handled by Multiple Imputation using a Fully Conditional Specification method with Bayesian Regression, details can be found below and in the online supplementary. Analysis was largely in line with the main study (see below) - in short, a change analysis was run wherein interactions were immediately decomposed into contrasts, with the differences between conditions over time compared to a likely effect size (.2 Likert units) using Bayes Factors. Sensitive results were taken to involve Bayes factors <1/3 and or >3.

## Results and learnings

in terms of mindfulness of the world being a good active control because it elicits the same expectations as mindfulness of mental states for the reduction of depression and anxiety, there was evidence for no difference between the interventions in expectations – therefore passing our initial manipulation check. This is the first time that Bayesian evidence for equivalence of expectations has been shown for a control group for mindfulness compared to the mindfulness intervention itself.

Regarding the FFMQ-sf, both the Observe and Acting with Awareness facets were higher in the Mental States group than the World group (*B*HN(0,.2) = 8.9, and 5.92, respectively). As all other facets and comparisons (along with our two bespoke ‘awareness of the world/mental states in the last hour’ questions) were insensitive, there is only partial evidence that our manipulation checks of mindfulness were passed. The finding on the Acting with Awareness subscale reproduces findings with this dataset in a previous study which showed a negative regression slope between this facet and hypnotisability (14). The AA facet features several questions about being aware of one’s actions, and therefore relates to one's awareness of intentions (i.e., a form of mental state). Interestingly, in the Buddhist literature, one of the four 'foundations' (i.e., objects of focus of central importance to the practice) include intentions (45) – and, taking inspiration, so did our mental states intervention.

The Observe facet, which we made no clear predictions about, has been shown to exhibit the expected positive intercorrelations with other FFMQ-facets (101–105) and negative correlations with psychopathological symptoms (106,107), but only in those with meditation experience. Whilst baseline performance may affect reliability, we may have found a result on this subscale because it is sensitive to differentiating meditators from non-meditators. On the other hand, the direction of this increase is somewhat surprising given that Baer et al (101) explained inconsistent results on this subscale by its focus on bodily and external perceptions, over cognitions – an issue worsened in the FFMQ-sf we used (compare 108 and 109, p. 236). We should consider that the Observe questions can be interpreted in two ways: As being aware of qualities as existing in the world, for example, colours, aromas, or sounds out there; or as being aware of perceptions of these qualities as experiences. If participants in the Mental States intervention interpreted the questions as referring to sensations and perceptions, it is not surprising that they scored highly on the facet. We will therefore extend the Observe scale by carefully wording two versions in terms of both awareness of the world, and awareness of perceiving the world, with a prompt instructing participants of this distinction. The Mental States group should score highly relative to the active control only when the scale refers to awareness of perceptions.

The main study would also benefit from a scale measuring an awareness of mental states in general. Upon review we feel that the FFMQ is unsuited to our needs as it deals largely with emotions, thought suppression, observation of the body and world, and actions. The same is true of the 5 scales used in the creation of the FFMQ, of other measures of mindfulness (109,110), and to a lesser extent scales dealing with decentring more directly (111,112). The decentring sub-scale of the trait version of the Toronto Mindfulness Scale (TMS; 113) meets the requirements of a manipulation check for mindfulness of mental states in the breadth with which it refers to mental states. Alongside these scales, an objective measure of metacognition using a Two-Alternate Forced Choice task coupled with a meta-d’ analysis of the resulting data will be used in the main study (see below).

Evidence was strong for a greater decrease in the Mental States condition compared to the World condition on the PHQ-4 Anxiety subscale (B=8.77) - combined with the sensitive finding of no difference in expectations for anxiety and depression, this finding is encouraging for regarding the Mindfulness of the World as an active control against which the benefits of mindfulness, seen as a metacognitive skill, can be shown when expectancies are controlled. Reliability of this sub-scale will be increased using a longer version from the same family of scales, which contains this two-item subscale, the GAD-7 (114). Although the two depression-related items of the PHQ-4 showed little change, in order to capture the broader construct of ‘mental health’, the PHQ-8 (115) (an expansion of this two-item measure of depression) will also be included in the main study.

The RRS measures rumination, a proposed core metacognitive mechanism of depression (116) of which there is evidence of change as a result of mindfulness interventions from several previous studies (117). Our finding that scores on this subscale reduced in the Mental States intervention compared to the world intervention indicates the former course was indeed successful in training metacognitive skills. However, thought suppression as measured by the WBSI, also a metacognitive mechanism of depression (118), was evidential only in decreases in the world condition, although lack of evidence in the mental states to world comparison cannot be interpreted as evidence of a lack of effect. Still, this may indicate that the world condition was indeed successful as a mindfulness intervention, at least compared to doing nothing in the waitlist group. For parsimony, these scales will only be included as exploratory scales in the main study.

In conclusion, we found some small indication of success in the pilot study - the main study will use these results in a data driven manner, with several changes to measures used listed above. Other methodological improvements are listed below.

# Main Study

## Hypotheses

On the theory that mindfulness is a metacognitive skill, our crucial manipulation check requires an increase in measures of metacognition and mindfulness in the Mindfulness of Mental States condition over the Mindfulness of the World condition. On the theory that mindfulness of the world contains some metacognitive training (e.g., control of attention), an increase in mindfulness and metacognition measures is also predicted in the Mindfulness of the World condition over that seen in the Waitlist control group.

Our second crucial manipulation check examines the theory that the World group is a good active control by testing for equivalence in expectancies between the World and Mental States groups. A final non-crucial manipulation check will examine the theory that between group differences are unrelated to intervention completion time, by testing that the difference in completion time is not more than would be needed to account for differences in outcomes.

On the theory that the metacognitive component of mindfulness accounts for much of the practice's positive effect on mental health, it is predicted that anxiety will decrease in the Mental States condition compared to the Mindfulness of the World condition. On the theory Mindfulness of the World has beneficial effects as well, anxiety will decrease as a result of this intervention, compared to a Waitlist group.

# Methods

## Participants

Participants will be recruited on social media websites (Facebook, Instagram, Twitter, and Reddit), using the third-party recruitment platforms (<https://www.findparticipants.com/>), Prolific (<https://www.prolific.co>), and MTurk (https://www.mturk.com/), via physical posters, through personal correspondence, or using the Sona platform to advertise to Undergraduate Psychology students at the University of Sussex. Participants will be either unpaid volunteers interested in meditation, paid £20 for participation via Prolific/MTurk, or students rewarded with research participation credits needed for completion of their degree. All participants will confirm to be above 18 years old and to have experienced <10 hours’ meditation practice. Ethical approval was received from the University of Sussex ethical committee (ER/MEL29/8). Informed consent will be obtained from each participant before participation. Estimations of required sample size (*N*=~220) can be found below.

## Procedure[[1]](#footnote-2)

To allow for efficient data collection with a larger sample, the main study will be fully automated using the Qualtrics survey platform. An initial link allows participants to sign up to the study and complete the pre-test survey, after which a random condition is automatically assigned using randomisation features of the Qualtrics platform. Follow up emails either inform participants they are in the Waitlist condition or contain a link to the first survey and meditation. This first survey contains an induction audio where the condition-relevant practice of mindfulness and the course structure is described, after which participants are asked about their expectations for the intervention to affect each measure. The next page of the survey contains the first day's meditation, after which participants are asked for the percentage of time that they paid attention to the practice. The next day's survey is sent out at 7:00AM GMT, which initially asks participants if they practiced mindfulness during a daily activity, before continuing onto the meditation and attention probe as in the first day. A reminder email is sent out each day for 3 days, after which an email is sent asking participants to complete the post-test survey in order to access the full intervention recordings, with a reminder for the post-test survey 3 days later, if it remains incomplete. Emailing was automated, handled partly through Qualtrics, and partly through an automated python script. After the 10th meditation the post-test survey is sent to participants immediately, or after 20 days in the Waitlist control group, which was the mean amount of time taken to complete the study in the pilot. All materials are provided in the online supplementary.

**Intervention Design**

Participant motivation is key to curtailing the trade-off between intervention length and fatigue, particularly with non-clinical samples using pre-recorded, automated interventions. With limited resources, we opted for a 10-day course following from previous similar studies (96,119). Our pilot study saw a dropout rate of about 1/3, prompting us to design a more interesting and engaging course. Influence was primarily taken from the Satipatthana Sutta, which functioned as a pre-made, varied selection of foci, structured in a progressive pattern of increasing subtlety (3).

**Induction**

Before expectations were taken, participants read an induction text defined mindfulness as focusing on the world around us, which in this case includes the body, or as ‘paying attention to what is happening in our minds’, including sensations by being aware that we are aware of sensory information, in the respective conditions. When distracted, participants were to gently return back to the object of focus. Participants in in the current study were directed to avoid elaborations, aided by simple categorisations such as seeing the breath as long or short. Participants were told that this exercise is not controlled breathing, and whilst they are welcome to try to relax into it if they like, they can be mindful no matter what state they are in and can let the breath come and go as it pleases. Slight wording changes between each condition made sure to reference either the world or mental states only. The induction featured several metacognitive skills that were exclusive to the mental states group: non-suppression (not stopping thoughts before they appear), non-clinging (not engaging with the content of thoughts), and equanimity/objectivity (that either positive or negative, thoughts and sensations are like objects passing through our awareness).

**World**

The Mindfulness of the World condition used mindfulness of breathing, posture, and the body (‘anatomical parts’), along with ‘activities’ during optional extra-curricular practice, all from the body Satipatthana (3). Participants attended to the world through various senses, with the focus on the world rather than the sensory states as such. To create a first-order mindfulness of the breath we instructed participants to ‘focus on’ and ‘become completely absorbed in’ the breath. Whilst there is no guarantee our instructions are encouraging the condition-relevant order of thoughts, intervention success would be demonstrated if the World condition cultivates mindfulness of mental states to an inferior extent than the Mental States condition.

Specifically, Day 1 is a body scan, and Day 2 a breath meditation. Days 3 to 7 handle a sensory modality each – sound, taste, sight, touch, and smell. On Day 5 participants are guided through attending to the world through touch sight and sound all at the same time, pervading a broad area of attention. Day 9 cycles through what has been learnt so far before ending on a world-based open-monitoring style of meditation. The final session is self-directed with minimal guidance using any of the previously learned techniques. In all these cases the foci of attention were described as objects in the world rather than sensory experiences.

**Mental States**

The mental states condition is a more faithful reproduction of the Satipatthana Sutta, which offers a ready-made progression of categorisations of mental states. We translate these concepts in a way we feel suitable for novice meditators unversed in Buddhist theory. Participants are to remain open to whatever the contents of their mind may be, whilst labelling their mental states using the categorisations provided (120). This intervention begins with an initial breath and body focus which participants could return to during the course, thus keeping a focus on sensory states controlled between conditions. The emphasis, unlike in the world intervention, is on the breath as an experience rather than a physical object.

As we detail this course, the relevant verse of the Satipatthana sutta can be found in square brackets - refer to (3) for more information. Day 1 focuses on the body [Anatomical parts], Day 2 on the breath [Breath], and Day 3 on sensory states as sensations [sense spheres, fourth Satipatthana]. Day 4 introduces an awareness of mental states (namely, thoughts and emotions), and talks about aspects of mindfulness like equanimity and ‘letting go’ [mind, third Satipatthana]. Day 5 talks about the cultivation of skillful states, including compassion [feelings, second Satipatthana], functioning as a ‘Loving-Kindness’/Metta style meditation. Day 6 talks about hinderances to mindful focus [third and fourth satipatthana], and integrates this with the labels of positive, negative, and neutral [feelings, second Satipatthana]. Day 7 focused on intentions, initially by asking participants to consciously choose to breathe in and out [aggregates, fourth Satipatthana]. Day 8 deals with meta-awareness and talks about different aspects of mindfulness one can be aware of [awakening factors & consciousness aggregate, fourth Satipatthana]. Day 9 introduces open-monitoring and non-doing style meditations (c.f. 3, p. 270). The final day is self-directed, whilst audio reminds participants of what has been learnt throughout the course.

## Measures

Measures were presented in the order listed below, see supplementary for copies of the survey and task.

**Metacognition task**: One crucial manipulation check utilises an objective measure of metacognition which has been successfully utilised in online studies in several papers to date (121–125). In this Two-Alternate Forced Choice (2AFC) task, participants are presented with two 6x6 cm black boxes – stimulus size is kept consistent across devices by asking participants to resize a box to the same size as a credit card, which provided a constant by which to adjust the entire page. These boxes are invisibly divided into 625 cells that are at least half filled with white dots. On each trial, one of the boxes is randomly chosen to have more dots than the other, and participants are tasked with selecting the box that has more dots. Five variations of dot positions were presented for 150ms each, giving the appearance of flickering dots, and a stimulus duration of 750ms (e.g. 123). In line with (121), the box with more dots was initialised at ~70 extra dots (a figure that will go up or down according to the staircase). The difference in the number of dots between the target and half-filled box is controlled by a ‘2 down 1 up’ (2D1U) staircasing procedure which altered the logarithm of dot-difference; where the difference decreases after two consecutive correct answers and increases after each incorrect answer. In the first 6 trials, dot difference changed by .4 natural log number of dots, with this reducing to a change of .2 for trials 6-11, and .1 after trial 12. Changes in staircasing were initiated during practice trials. 2D1U staircasing should lead to ~71% accuracy for each participant on this task (126). Answers were given by pressing the ‘E’ or ‘I’ key, and the choice was not time limited. 26 practice trials were run where feedback was given, with the words ‘correct’ or ‘incorrect’ displayed, and the chosen square highlighted in either green or red, respectively. The task proper consists of 4 blocks of 42 trials each (168 total) in which no feedback is given, and confidence is rated after every task on a 1 ‘guessing’ to 6 ‘certain’ scale. The data will then be analysed using the meta-d’ method to estimate the correspondence between task accuracy and performance (see analysis section below). The task was programmed in JavaScript and integrated into the Qualtrics survey using Qualtrics’ JavaScript API (code available in online supplementary and GitHub listed below).

Several scale measures were also used, all of which were reworded to refer to the last week, and scores were calculated as means. Pre-registered scales are:

**Toronto Mindfulness Scale – Decentring** subscale: The 7-item Decentring subscale of the trait version of the Toronto Mindfulness Scale (TMS-D; 127) was selected as a measure of awareness of mental states. Scores are given on a Likert-type Scale ranging from 0 (Not at all) to 4 (Very much).

**Generalised Anxiety Disorder** scale: The GAD-7 (128) is a 7-item scale which measures anxiety. Scores range from 0 (not at all) to 3 (nearly every day).

**Patient Health Questionnaire**: the short-form PHQ-8 (115) is an 8-item scale which measures depression. Scores range from 0 (not at all) to 3 (nearly every day).

**Expectations:** After the induction text, participants were presented with the following question:

“Mindfulness has been claimed to produce several effects. We want to know what you actually expect about this two-week intervention, given what you have just read.

For each question below, please use the sliders to indicate by how many scale points you expect taking this course will change your answer. We have provided the original scale labels for reference, but please use the sliders to tell us the number of units you expect your score to increase or decrease by compared to before the course.

For example, say that before taking this course you answered the question 'Over the last week, how often have you had trouble relaxing?' with the answer '3. Moderately' on the 5-point scale provided. if you expect that, by the end of this course, your answer will have changed to '2. A little' on the same scale, then you are expecting a reduction of 1 point on the scale, and your answer below would be '-1'.

Likewise, if you expect your score will remain the same after versus before the intervention, say 0. If you think your score will be larger by a certain number of units say +that number, e.g., +2; if you think your score will have reduced by a certain number of units say - that number, e.g., -2.

Please check the axis label for each section before answering!”

One item will be included for each exploratory scale, along with each item of the TMS, GAD-7 and PHQ-8. The questions, scale-points and labels will be the same as in the original scales, symmetrical around 0. In analysis, we will create an average expectation score for each scale with more than one expectation related question (i.e., TMS, GAD-7, and PHQ-8), whilst the single item expectations for exploratory scales will be analysed separately.

**Completion time:** Time taken in days to complete the intervention will be measured to check that this variable does not account for differences in outcomes.

The following scales from the pilot study will also be ran for exploratory analyses (see pilot study methods section in online supplementary for more info):

* The RRS (129)
* The 15-item WBSI (118)

The following scales are also exploratory but did not feature in the pilot study:

1. **FFMQ Observe – Perceptual vs World versions:** Following from the Observe sub-scale providing sensitive evidence in the pilot study, we have taken the Observe subscale from the full FFMQ (101), and reworded it to reflect an awareness of the world and mental states, separately. The scale was structured so that a first order question was asked before the corresponding second-order item. For example, a worldly observation question asks, “I pay attention to sounds in the world, such as clocks ticking, birds chirping, or cars passing.”, which is followed by a mental states focused variant “I pay attention to hearing sounds, such as clocks ticking, birds chirping, or cars passing.”. The last question of the Observe subscale “I pay attention to how my emotions affect my thoughts and behaviour” was removed from the questionnaire as it does not refer to sensory perception. The two versions of the scale can be found in the supplementary materials.

* **Engagement:** At the beginning of each day’s survey, before meditating, participants will be asked if they were mindful during an activity after the previous session. After each practice, participants will be asked how long they spent focusing on the task just completed. At the very end of the post-test survey, participants will be asked how well they stuck to the course content.

# Analysis Plan

**Multiple Imputation**

Missing data will be imputed using Multiple Imputation methods. Surveys will force responses on all questions, and so we only expect missing data due to drop-outs. Condition will be included in all imputation models, as the main ‘covariate’ of missingness we require to be equalised between conditions for our analyses, and as differences in intervention content are most likely a motivator of dropouts. Computing data separately by condition may make little effect either way (131).

Our dataset will contain 73 items and a cognitive task, plus additional auxiliary variables, per-test. Although an item-level analysis is recommended for MI (131), along with one which is inclusive of available variables (132), in our case this would create an unwieldy regression equation that will likely not converge (see pilot study; 133 pp. 259-271). In line with the approach suggested by Plumpton et al., (134), we will impute missing data on each item using all pre-test items on that scale and sub-scale means for other scales in the dataset – in the case where the entirety of post-test scores are missing, a scale-level analysis should be suitable anyway (135). Metacognitive efficiency will be calculated for each participant before imputation and will similarly rely on subscale-level pre-test predictors.

Multiple Imputation will be handled using a fully conditional specification approach (136 pp. 116-118; 137), with a Bayesian Regression imputation method (136,138), using the ‘mice’ R package (139). Imputed values will be unconstrained by possible scale values, including negativity (c.f. 140,141). 100 imputed datasets will be generated, in accordance with the upper-end of that tested by Graham, Olchowski, & Gilreath (142; see also: 143). Number of iterations will be estimated by the percentage of participants with missing post-test data, although a minimum of 30 will be used (144,145). Each statistical test (along with means and SEs) will be carried out on each imputed dataset separately, and the mean of these results are presented in the table below and taken as the final result.

**Metacognitive Efficiency and Sensitivity**

The metacognition task (see ‘materials’ above) will be analysed using the meta-d’ method (95,146). Meta-d’ is a measure of the correspondence between task accuracy (selecting the correct box – the ‘type 1’ task) and confidence on that task (type-2 task), in a way which is unaffected by one’s idiosyncratic use of the confidence scale (i.e., bias). Meta d’ is the Type I d’ that would exist if the first order discrimination was based on the same signal and noise first order evidence distributions as the confidence decisions – this is called ‘metacognitive sensitivity’. As this metric is in type-1 units, it can be divided by a participant’s actual type-1 performance to estimate how far off from metacognitively ideal their performance was (i.e., meta-d’/d’; ‘metacognitive efficiency’). A score of 1 then indicates one was ‘metacognitively ideal’, although meta-d’ can exceed d’ for several proposed reasons (147). Whether this is the best way of controlling for Type I performance in assessing metacognition is a point we now explore.

Metacognitive efficiency is a ratio, and this way of factoring d’ into the metric may introduce more noise than it removes (roughly, the proportional error of a ratio is the sum of proportional errors of its terms). To examine this possibility, data from two previous similar studies were examined for changes in meta-d’ and meta-d’/d’ in their group\*time interaction (94,98; exactly which data is detailed in ‘models for H1 below, models were fitted individually by maximum likelihood estimation). Results show that meta-d’ recorded a change of M=0.61, SE=0.29 and whilst meta-d’/d’ saw the mean halved, the SE did not see notable reductions (M=0.33, SE=0.24; N.B. SEs from Schmidt et al. adjusted to Carpenter et al.’s N=61). Typically, one can logarithmically transform a ratio measure to normalise the distribution, as suggested in previous papers on meta-d’ (e.g., 95,149). In practice, the log transformed meta-d’/d’ from these previous studies had M=.30, SE=.25 in ln units. Crucially, the estimated required sample sizes were meta-d’ N=110, meta-d’/d’ N=300, log(meta-d’/d’) N=330. That meta-d’/d’ introduces more noise than it takes out from the meta-d’ measure, and that this appears unaffected by logging this ratio, is worth noting for future research. A further widely used method for controlling for a variable is of course regression; and so we also tried analysing meta-d’ as the DV, with d’ as a covariate. Doing so yields change data from previous studies of M=0.54 (with SE=0.29, as above), with a required sample size estimated at N=160. So, regression turns out more sensitive than taking a ratio. Our study will use this covariate adjustment method to analyse meta-d’ data, which we call ‘Adjusted Metacognitive Sensitivity’. Models will be fit on an individual basis with a Bayesian estimation method using by porting Fleming’s Hmeta-d (149) MATLAB (150) toolbox into R. Group-level hierarchical model fits as suggested in (149) would be unsuitable for the adjustment method we rely on as estimations of meta-d’ values are in part based on estimations of meta-d’/d’ at the group level, and thus become non-independent.

**Change Analysis**

We will contrast the Mindfulness of Mental States condition against the Mindfulness of the World condition, with the latter in turn compared to the Waitlist condition. We rely on a change analysis method by decomposing the interaction between group (Mental, World, Waitlist) and time (pre vs. post) into contrasts between 1) the mental states and the world condition and 2) the world condition and the Waitlist condition. T-ratios and associated p-values will be calculated from follow-up contrasts on an ANOVA of post-test value by condition, although these are not pre-registered as we rely on a Bayesian analysis upon which we draw conclusions.

**Bayes Factors**

Analyses are interpreted with respect to Bayes factors (*B*), although p values are provided as well (148,149). A *B* of above 3 indicates “substantial” (150) or, better, “moderate” (151) evidence for the alternative hypothesis (H1) over the null hypothesis (H0); thus by symmetry a *B* below 1/3 indicates substantial (/moderate) evidence for H0 over H1 (“substantial” in the sense of just worth taking note of). *B*s between 3 and 1/3 indicate the data collected do not sensitively distinguish H0 from H1. Thus, we will report that there was no effect only when *B* < 1/3. H0 will always be modelled as a spike on 0 (152, pp 24-26). Here, *B*H(0, x) refers to a Bayes factor in which the predictions of H1 were modelled as a half-normal distribution with an SD of x where x scales the size of effect that could be expected (*see* 153). To indicate the robustness of Bayesian conclusions, for each *B*, a robustness region is reported (154), giving the range of scales that qualitatively support the same conclusion (i.e. evidence as supporting H0, or as supporting H1, or there not being much evidence at all), notated as: RRconclusion [x1, x2] where x1 is the smallest SD that gives the same conclusion and x2 is the largest. “Conclusion” means “*B* < 1/3”, or “1/3 < *B* < 3”, or “*B* > 3”.

## Models of H1 for Bayes factors

*See online supplementary for data and r code to reproduce the following analyses.*

Bayes factors will use a point estimate of 0 for the model of the null hypothesis (H0; 152).

**Adjusted Metacognitive Sensitivity**

Data from two previous similar studies was available - means differences and SEs from the group by time interactions for their perception measures only (similar to the task used in our own study) were extracted. Schmidt et al. (94) had a similar paradigm to the current study, pairing an 8-week mindfulness of the body to a mindfulness of mental states (for this study the SE was adjusted by the ratio of the square root of sample sizes). Carpenter et al. (98) trained individuals directly on either type-1 task accuracy or metacognition - we extracted data from those stimuli participants were trained on. The mean interaction (pre vs post by metacognitive training vs control) for these studies was M=0.54, SE=0.29 meta-d’ units, adjusted for type-1 d’ (see above). Thus, our prior will be set to a half-normal with an SD of 0.5 meta-d’ units (code, data, and sources available in supplementary).

**d’**

We expect equivalent task performance in d’ as a result of staircasing task difficulty. It is not necessary to assume equivalent d’s for our analysis of meta-d’, because we adjust for d’. Nonetheless we will test this assumption with a Bayes Factor between the mean d’ of each group, against a model of H1 with an SD of the unadjusted meta-d’ difference between groups. Thus, we will examine the amount of type-1 d’ that would be needed to explain the recorded difference in meta-d’ (i.e., type-2 performance in d’ units). Note this test is non-crucial.

**Likert scales**

The SD of the half-normal distribution should be set to a roughly expected scale of effect, or half a plausible maximum (153). Thus, we base our estimates of expected effect size under the experimental hypothesis on effect sizes found in previous studies (c.f. 154). Studies were considered for use in calculation of a model of H1 if they were short (10 minutes, 10-14 days) online controlled trails with Likert-scale measures and available with cell means available for measures at pre- and post-test. Four studies using the Learning Mindfulness Online intervention upon which our own was based were located (96,119,155,156), along with 3 others using the Headspace app (157–159). The average interaction for mean scores between conditions over time, on a per-question basis and placed on a common 4-point Likert-scale, was .2 Likert units, which will be used as the model of H1 for all scale measures.

**Expectancies**

Expectancy scales for mindfulness (TMS), anxiety (GAD-7) and exploratory scales will be administered - averages on each of these will be calculated. As we expect a roughly 0.2 Likert unit change on each outcome variable, this is the relevant amount of expected change we need to rule out. We assume that an expectancy to change by X units could at most produce a change of X units. Thus, expectancy changes more like 0.4 rather than 0.2 units would be needed to account for an outcome change of 0.2 units. Further, in this case, smaller differences in expectancy are not more likely in terms of explaining a change in outcome variables than larger changes. Thus, H1 would be modelled as a normal distribution with a mean of 0.2 Likert units and SD = 0.1. If expectancy has not been controlled, we will enter it as a covariate in all above analyses, and conclusions will follow from this analysis.

**Time on intervention**

We will also take the time taken to complete the interventions into account – that is, we will evaluate equivalence between interventions for the effect that time taken to complete that intervention had on mindfulness training. In order to estimate the relevant effect size on which to base our model of H1, we will regress TMS scores against time taken to complete an intervention, and then divide the raw difference in TMS scores between interventions by this slope. Our estimate of the amount of time taken to complete the intervention that would be needed to explain the difference in TMS scores between interventions will be the SD of a half-normal, against which the obtained difference in intervention completion time between interventions will be compared, with a Bayes Factor. This analysis is considered non-crucial.

# Sample size estimation

**Scale Measures**

We estimated the sample size required to reach a result sensitive to a Bayes Factor of 1/3 and 3. The sample SE was modelled using 100 participant mean difference scores over time on a random selection of 7 items (i.e., the length of the TMS-D and GAD-7) and 8 items (for the PHQ-8) from the FFMQ-sf in the pilot study. The SD of the resulting distribution of sample means was used as the SD of the distribution of our hypothetically obtained data. Using the method described by (160), this sample SE was multiplied by the square root of: the harmonic mean of the group size in the pilot study divided by the estimated required sample size (per group), for a final sample SE. Obtained data were modelled with a mean of 0, whilst H1 was a half-normal with SD=.2 Likert units, as estimated above. Results across imputed datasets were meaned, and the minimum sample size leading to a Bayes Factor <.33 extracted. As a result of this procedure, we estimate a minimum of 180 (for the PHQ-8) to 220 (for the TMS-D and GAD-7) participants would be needed for comparisons between the mental states and world group, and 150 (PHQ-8) to 180 (TMS-D and GAD-7) participants for comparisons between the world and waitlist group.

**Expectations**

Subsequently, a similar analysis was run for expectations, using the H1 of a normal distribution with Mean = .2, SD=.1 Likert units (See ‘models of H1’, above). Seeking to avoid single item-measures for key outcome variables, a sample SE was estimated for a random selection of 4-7 FFMQ items, as above, as we had little other information to go on. Required sample size (n=120) seemed to plateau around 5 questions. One question will be asked for each item of the GAD-7, PHQ-8 and TMS-D for completeness.

**Meta-d’**

Previous likely effect size for meta-d’ is estimated at M=0.5, SE=0.29 meta-d’ units (see above). H1 was thus modelled as a half-normal with SD=.5. The SE for a given sample size was estimated as: 0.29 times the square root of: the harmonic mean of the group sizes in Schmidt et al. and Carpenter et al. (harmonic n=19), divided by the estimated group size required for our own study. Thus, an estimated minimum required effect size was obtained of 160 participants in total.

We will thus run 220 participants and stop data collection when either the Bayes factors of all crucial tests are above 3 or less than 1/3, or we have reached a maximum of 300 participants in total.



















Pre-registered Results

**Sample**

The average age of our sample was 23.62 with a range of 18-71. 150 participants were women, 71 men, with 8 opting out of or choosing ‘other’ for gender (free text inputs found in full dataset). We saw a high dropout rate of around 55%.

*Table 1: Sample size and drop-out rates.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Control | Mental | World | Total |
| Per-protocol | 24 | 34 | 40 | 98 |
| Returned | 0 | 4 | 1 | 5 |
| Dropout | 49 | 35 | 31 | 115 |
| Total | 73 | 73 | 72 | 218 |

5 individuals who dropped out of the study opted to return to fill out post-test. These participants were kept in when running multiple imputation algorithms on the full dataset as we did not pre-register their removal. As these participants did not complete the full study, they are not featured in any analyses of the per-protocol data. 2 participants who attained d’=0 on the Dots task were removed from the dataset as this precludes the calculation of the M-ratio, and represents a clear lack of engagement with the task.

**Expectancies**

*Table 2: Differences in expectations between intervention groups*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Mental States** | **World** | **Group Interactions** | | |
|  | **Mean (SE)** | **Mean (SE)** | **Mean (SE)** | ***B*N(.2,.1)** | **RR *B*1/3<*B*** |
| TMS | 1.12 (0.21) | 0.79 (0.19) | 0.33 (0.28) | 1.72 | [0.00, 1.66] |
| GAD | 0.46 (0.18) | -0.02 (0.23) | 0.48 (0.29) | 2.44 | [0.00, 3.39] |
| PHQ | 0.21 (0.16) | 0.02 (0.19) | 0.19 (0.25) | 1.24 | [0.00, 0.97] |
| SOW | 1.11 (0.20) | 1.38 (0.27) | -0.27 (0.34) | 1.29 | [0.00, 1.35] |
| WBSI | 1.05 (0.27) | 0.79 (0.30) | 0.26 (0.40) | 1.19 | [0.00, 1.43] |
| RRS | 0.49 (0.19) | 0.46 (0.24) | 0.03 (0.31) | 0.83 | [0.00, 0.86] |

*Note: ‘Mental States’ and ‘World’ columns show per-group mean expected differences over time. In group-by-time interactions, positive mean scores indicate that expectations were higher in the mental states group over the world group. These data were not multiple-imputed.*

Expectancies were gathered after participants had read a short explanation of what their condition would entail. If expectancies were equalised between conditions, the Bayes Factors in Table 2 would evidence the null (<.33). All recorded expectations were insensitive to a difference between interventions. Thus, the placebo effect, which must be equalised between conditions to determine if the world condition is truly less effective, remains uncontrolled. Thus, more data are needed, and the results below should be interpreted with caution. Expectancies were generally higher for the Mental States group than the world group, with the exception the Sensory Observation of the World scale, which, perhaps unsurprisingly, had higher expectations for an improvement during the World intervention.

**Time Taken to Completion**

In the per-protocol data, the average time taken to complete the intervention was M=15.6, SE=0.72 in the Mental States condition, and M=14.90, SE=0.69 in the World condition. A regression of TMS change scores on the time taken to complete the intervention resulted in a raw regression slope of β=0.03 TMS Likert units per-day. The absolute difference in change scores on the TMS-D between interventions was then divided by the aforementioned raw regression slope for a model of H1 describing the effect of the time taken to complete an intervention on outcome variables, H1= 0.29 Likert units/0.03 Likert units per day = 9.67 days, with the resulting Bayes Factor sensitive to the null, BF=0.2, RR=[6, >20 days].

**d' equivalence**

Using the per-protocol data, the mean d' and meta-d' values for each of our interventions is listed in Table 2. A Bayes Factor testing the difference in d' against an H1 of the difference in meta-d’ was sensitive to the null of no difference (BF=0.21, RR=[0.08, >5.00]). Thus, d' can be considered equivalent between our interventions (See Table 5 for relevant cell means).

Table 3. Means and SEs for intervention conditions, and their difference, for d’ and meta-d’

|  |  |  |  |
| --- | --- | --- | --- |
|  | **World** | **Mental States** | **Difference** |
| d' | -0.04 (0.03) | -0.02 (0.02) | -0.02 (0.04) |
| meta-d' | 0.13 (0.08) | 0.00 (0.08) | 0.13 (0.00) |

*Note: each cell shows Mean differences over time, with Standard Errors in Brackets.*

**Group-by-time interactions**

*Table 4: Mean differences and Bayes Factors on the Multiple-Imputed data*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **MS-World** | | | **World-Waitlist** | | | **MS-Waitlist** | | |
| **Measure** | **H1** | **Mean** | **BHN** | **RR1/3<B<3** | **Mean** | **BHN** | **RR1/3<B<3** | **Mean** | **BHN** | **RR1/3<B<3** |
| TMS-D | 0.20 | -0.13 (0.14) | 0.34 | [0.00, 2.87] | **0.33 (0.12)** | **152.24** | **[0.06, 3.20]** | **0.20 (0.12)** | **7.11** | **[0.04, 1.56]** |
| SOW 1st | 0.20 | **-0.35 (0.12)** | **0.14** | **[0.08, >5.00]** | **0.32 (0.11)** | **128.19** | **[0.05, 3.45]** | -0.03 (0.11) | 0.46 | [0.00, 1.85] |
| SOW 2nd | 0.20 | **-0.30 (0.12)** | **0.18** | **[0.10, >5.00]** | **0.41 (0.12)** | **867.78** | **[0.05, 4.63]** | 0.12 (0.11) | 2.33 | [0.00, 1.11] |
| PHQ-8 | 0.20 | **-0.18 (0.09)** | **7.24** | **[0.06, 1.41]** | **-0.36 (0.09)** | **26135.55** | **[0.03, 4.88]** | **-0.54 (0.09)** | **86184332.32** | **[0.02, >5.00]** |
| GAD-7 | 0.20 | **0.25 (0.16)** | **0.31** | **[0.10, 3.39]** | **-0.20 (0.15)** | **10.52** | **[0.03, 1.87]** | 0.06 (0.15) | 0.77 | [0.00, 1.71] |
| RRS | 0.20 | 0.01 (0.08) | 0.36 | [0.00, 2.39] | **-0.35 (0.09)** | **36756.89** | **[0.03, 4.93]** | **-0.34 (0.08)** | **6137.60** | **[0.03, 4.98]** |
| WBSI | 0.20 | **0.12 (0.12)** | **0.30** | **[0.13, 4.00]** | **-0.19 (0.11)** | **5.32** | **[0.05, 1.34]** | -0.07 (0.11) | 1.04 | [0.00, 0.97] |
| Adj. meta-d' | 0.50 | **-0.06 (0.09)** | **0.13** | **[0.18, 4.87]** | 0.03 (0.09) | 0.62 | [0.00, 3.73] | **0.10 (0.08)** | **13.04** | **[0.13, 2.70]** |
| HM-ratio | 0.30 | 0.05 (0.07) | 0.76 | [0.00, 2.42] | **0.05 (0.07)** | **7.97** | **[0.08, 2.39]** | **0.10 (0.07)** | **9.59** | **[0.09, 2.08]** |

*Notes: Cells in bold indicate sensitive Bayes Factors and their related statistics. Mental States vs. Waitlist group greyed out to indicate this analysis is exploratory.*

To briefly summarise the MI results, both interventions were well distinguished from the waitlist group, but did not differ from one another, with the exception of the PHQ-8 depression scale, on which the Mental States group increased over and above the World group. As many of our results were insensitive, this indicates a clear need for more data.

Whilst multiple imputation was our main pre-registered analysis protocol, the extent of our missing data could not be accounted for well by these models, as illustrated by the extent of some of our mean differences and Bayes factors in the table above. This is unsurprising as 55% missing data is far above the recommended upper limit of 5% of missing data (Lee & Huber, 2021). We will next analyse the per-protocol dataset of participants who completed all 10-days of meditation, and waitlist controls who completed post-test.

Non-pre-registered Results

**Engagement & Evaluation**

Whilst feedback was not forced, of those who reached the post-test survey, many chose to report on their feelings towards the interventions. 84% reported doing the course exactly as described or meditating more in the world condition, with 79% in the Mental States condition reporting the same. 80% of the World condition reported the intervention reported the course as ‘very useful’, whilst 62% of the Mental States condition found their course ‘very useful’. 95% of participants reporting on the world condition felt their intervention was ‘authentic mindfulness’, with 81% of participants in the mental states group reporting similarly. Of those who completed all 10 sessions, 64% of the world condition reported a mean focus over the 10 sessions of at least 70%, and 60% of the mental states condition reported the same. Those who completed the 10 sessions, 55% of the world condition reported participating daily activities on at least 7 days, with 45% of the mental states condition reporting similarly. Overall, it appears the world condition was slightly more engaging than the mental states condition to participants.

**Per-protocol group-level changes over time**

*Table 5: Group-means and SE at each time-point in the Per-protocol dataset.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Waitlist** | | **World** | | **Mental States** | |
| **Category** | **Measure** | **Pre** | **Post** | **Pre** | **Post** | **Pre** | **Post** |
| Mindfulness | TMS-D | 1.65 (0.12) | 1.72 (0.14) | 1.49 (0.13) | 2.03 (0.13) | 1.57 (0.13) | 1.82 (0.14) |
| Observe 1st | 3.36 (0.15) | 3.35 (0.16) | 3.12 (0.12) | 3.61 (0.11) | 3.35 (0.11) | 3.32 (0.12) |
| Observe 2nd | 3.07 (0.15) | 3.01 (0.18) | 2.85 (0.12) | 3.34 (0.13) | 2.98 (0.13) | 3.07 (0.12) |
| Mental Health | PHQ-8 | 1.51 (0.16) | 1.33 (0.21) | 1.23 (0.1) | 0.83 (0.09) | 1.3 (0.11) | 0.76 (0.09) |
| GAD-7 | 2.07 (0.17) | 1.9 (0.21) | 2.56 (0.11) | 1.98 (0.14) | 2.3 (0.13) | 1.88 (0.2) |
| RRS | 2.46 (0.15) | 2.35 (0.19) | 2.42 (0.09) | 2.05 (0.09) | 2.35 (0.11) | 2.03 (0.11) |
| WBSI | 3.78 (0.17) | 3.44 (0.22) | 3.62 (0.12) | 3.25 (0.13) | 3.67 (0.12) | 3.2 (0.17) |
| Metacognition | d' | 1.18 (0.03) | 1.21 (0.03) | 1.17 (0.02) | 1.15 (0.01) | 1.21 (0.03) | 1.18 (0.02) |
| HM-ratio | 0.6 (0.07) | 0.51 (0.06) | 0.58 (0.05) | 0.58 (0.04) | 0.38 (0.05) | 0.51 (0.07) |

*Note: Standard Errors shown in brackets*

*Figure 1: Change in group means over time for key outcomes in the Per-protocol dataset.*

A graph showing different colored bars

Description automatically generated

*Note: Change from pre to post-test in the per-protocol dataset, SE in brackets.*

In the per-protocol data, changes to scale measures were roughly in the hypothesised directions – with increases to the TMS-D and reductions in scale measures of mental health across interventions, and little movement in the waitlist group. Differences between intervention groups appear rather minimal by comparison. The exception here is the SOW scale, which recorded positive changes in the world condition, and little movement in the mental states group. The M-ratio showed little change, although is in the expected direction of an increase in the Mental states condition over the world condition, whilst scores decreased over time in the waitlist group. Below we test these group-by-time interactions using Bayes Factors on Multiple-Imputed and Per-protocol data.

**Group-by-time interactions**

*Table 6: Mean differences and Bayes Factors on the per-protocol dataset*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **MS-World** | | | **World-Waitlist** | | | **MS-Waitlist** | | |
| **Measure** | **H1** | **Mean** | **BHN** | **RR1/3<B<3** | **Mean** | **BHN** | **RR1/3<B<3** | **Mean** | **BHN** | **RR1/3<B<3** |
| TMS-D | 0.20 | -0.29 (0.21) | 0.39 | [0.00, 0.24] | **0.48 (0.19)** | **6.68** | **[0.11, 2.81]** | 0.18 (0.20) | 1.28 | [0.00, 1.43] |
| SOW 1st | 0.20 | **-0.52 (0.17)** | **0.21** | **[0.12, >5.00]** | **0.50 (0.18)** | **10.00** | **[0.09, >5.00]** | -0.03 (0.18) | 0.61 | [0.00, 0.44] |
| SOW 2nd | 0.20 | **-0.40 (0.17)** | **0.25** | **[0.14, >5.00]** | **0.55 (0.17)** | **22.00** | **[0.07, >5.00]** | 0.15 (0.17) | 1.22 | [0.00, 1.19] |
| PHQ-8 | 0.20 | -0.15 (0.13) | 1.45 | [0.00, 1.30] | -0.22 (0.15) | 2.10 | [0.00, 2.42] | **-0.37 (0.16)** | **5.89** | **[0.10, 1.40]** |
| GAD-7 | 0.20 | 0.17 (0.23) | 0.53 | [0.00, 0.37] | -0.42 (0.24) | 2.48 | [0.00, >5.00] | -0.25 (0.26) | 1.36 | [0.00, 2.01] |
| RRS | 0.20 | 0.05 (0.12) | 0.39 | [0.00, 0.24] | **-0.26 (0.14)** | **3.37** | **[0.15, 0.37]** | -0.21 (0.13) | 2.47 | [0.00, 2.68] |
| WBSI | 0.20 | -0.10 (0.18) | 0.96 | [0.00, 0.86] | -0.03 (0.19) | 0.75 | [0.00, 0.61] | -0.13 (0.21) | 1.05 | [0.00, 1.08] |
| Adj. meta-d' | 0.50 | **-0.17 (0.12)** | **0.10** | **[0.14, >5.00]** | 0.07 (0.13) | 0.40 | [0.00, 0.61] | **0.23 (0.12)** | **2.53** | **[0.00, 4.29]** |
| HM-ratio | 0.30 | 0.13 (0.09) | 1.37 | [0.00, 1.40] | 0.09 (0.10) | 0.73 | [0.00, 0.71] | **0.22 (0.10)** | **5.30** | **[0.07, 0.67]** |

*Notes: Cells in bold indicate sensitive Bayes Factors and their related statistics. Mental States vs. Waitlist group greyed out to indicate this analysis is exploratory. Models of H1 on BCT-M statistics are based on a re-analysis of Carpenter et al. (2019) and Schmidt et al. (2019).*

*Figure 2: Bar graph of group-by-time interactions, decomposed into comparisons between groups (per-protocol results)*

A diagram of different colored bars

Description automatically generated

*Note: Mental-States Waitlist comparison bar colours are desaturated to indicate this analysis is exploratory. Error bars show 95% Confidence Intervals.*

Sensitive analyses of the per-protocol data display a consistent pattern which reflects the analysis of the Multiple Imputed datasets: intervention groups were not differentiated from one another, but were more effective than waitlist. Actually, these sensitive results comparing our interventions trended in the opposite direction to that which we hypothesised – with higher change scores in the World group over and above those seen in the Mental States group. However, mostly insensitive Bayes Factors in both analyses, and examination of the 95% Confidence Intervals in Figure 2, clearly display a high degree of uncertainty, and a need to gather more data.

Discussion

This study tested a novel control intervention for mindfulness therapies - a minimal mindfulness control condition, which we evaluated against a full mindfulness condition and a waitlist control. Evidence from several variables in both the per-protocol dataset and when missing data was handled by Multiple Imputation indicated that each of our interventions were generally more effective than waitlist at improving well-being and metacognitive skills. On the other hand, evidence was largely against the hypothesis for the superiority of the Mental States intervention over the World intervention. Still, we are yet to reach minimum sample size estimates, and thus predictably record largely insensitive results.

**Manipulation Checks**

On our scale measure of mindfulness, the TMS-D, results indicated that both interventions were distinguished from waitlist, whilst the comparison between interventions was insensitive. As this validated scale functions somewhat as a manipulation check, detecting equivalence or superiority one way or the other between our interventions is crucial to evaluating the source of improvements as a result of our interventions. Still, that these interventions were distinguished from wait-list is evidence of a successful intervention in one regard: (self-reported) mindfulness appears to have been trained. Note, however, that the extent of our missing data was likely beyond that which Multiple Imputation algorithms can handle. In the Per-protocol data the comparison between mental states and waitlist groups on the TMS-D was insensitive.

We also examined mindfulness using a novel SOW scale - a rewording of the FFMQ Observe subscale into first- and second-order observation styles. Across both SOW sub-scales, we recorded evidence to the null regarding the superiority of the Mental States group over the World group, with evidence tending in the other direction, record a sensitive increase in the World group over the Waitlist group. These conclusions held between MI and Per-protocol analyses. Such results are perhaps unsurprising, where this scale probes an awareness of the outside world. One possibility is that the distinction between orders of sensory observation was confusing to some participants. Looking to Figure 1, we can see both 1st and 2nd order subscales of the SOW had similar increases in the World condition, whilst the Mental States group saw a decrease in 1st order observation, and an increase in 2nd order observation. Thus, perhaps through our Mindfulness of Mental States condition, participants are introduced to this distinction. Subtracting these subscales from one-another may help reveal this trend in future uses of the scale.

That our manipulation checks were largely failed suggests we may not have successfully operationalised mindfulness. Whilst utmost care was taken to balance our two novel interventions, these are still based our own readings of early Buddhist suttas and so necessarily diverge from standard clinical implementations of the practice (e.g., 8), and of course are untested outside of this study. For one potential flaw, the Mental States intervention is a crash course in Satipatthana - working through the key mindfulness sutta in 10 short days, mastery over which can take a lifetime (or several). By comparison, the World group is a much gentler introduction to mindfulness. Perhaps greater balance can be achieved between these interventions by reducing the difficulty of the Mental States intervention, and by increasing intervention length in order to allow for a gradual learning curve. None-the-less, no single study can be considered a substantive test of our leading hypothesis. The wide variety of approaches to mindfulness meditation suggest that replication by other research groups would be necessary to adequately test the theory behind the current article. For our part, whilst the script for the current study was written by the first author, our replication of the current study featuring a new measure, as mentioned above, will use a script written by the second author.

**Metacognition**

Metacognitive efficiency, namely our bespoke variant of Adjusted Metacognitive Sensitivity (AM-d'), is our key outcome of interest. Across both Multiple Imputed and Per-protocol datasets, evidence was found for an increase in the Mental States group over the Waitlist group in both the HM-ratio and AM-d'. However, evidence against the hypothesis of the superiority of the Mental States group over the World group was recorded for AM-d' across both datasets. Thus, our key metric of interest provides substantive evidence of the failure of this experiment to find an increase in metacognition in the intervention to which we aimed to isolate training of this faculty.

Note that although we consider metacognitive efficiency to be our key metric of interest, we have operationalised this in the visual domain. Thus, we imply that our metacognitive decentring training will enhance metacognition in a domain-general manner. The domain generality of metacognition is currently a point of contention in the literature (161,162, paper 3 current thesis), and so we might not be set up to detect the changes in metacognition relevant to our theory. Fortunately, meta-d' is a highly flexible measure, and we are currently running this same experimental design, using a metacognitive measure of mindfulness formed by the inclusion of confidence ratings to the existing Breath-Counting Task of Levinson et al. (2014; see paper 2, current thesis).

Our mindfulness of the world condition was intended to feature all components of mindfulness except our proposed all important factor of, in various forms, metacognitive awareness. A lack of difference between training in mindfulness of world versus the full mindfulness of mental states intervention would suggests that mindfulness is effective via non-metacognitive components, and perhaps solely by virtue of its assumed effectiveness. However, expectations to improve over the course of each intervention were not confirmed to be equal, as would be required to conclude that the placebo effect accounted for improvements in one condition over the other. Whilst not inferentially tested, perceived authenticity was higher for the world condition and so one might presume that any placebo effects would boost scores in this condition in tandem with this, although this may also simply reflect a more enjoyable course overall. It does appear that interventions were completed in roughly the same time-frame, and moreover the difference in this time to completion had no discernible effects on outcome measures.

**Limitations of theory**

Of course, the point of failure in our design may lie at the theoretical level. Many practitioners will take issue with our understanding of mindfulness as a necessarily metacognitive exercise in its truest form. Mindfulness of the World may have its own specific effects - providing a tranquil escape from thoughts which, ironically (considering the theory underlying the current study) might provide a sense of distance and perspective from one's worries. In this sense, metacognitive outcomes - a changing perspective on internal states, could result from a practice focused on their absence. Or, more simply, Mindfulness of the World might reflect the practice of Samatha, wherein one meditates on some simple object of meditation in order to still the mind. The proposed resulting state of 'tranquillity' has much in common with the modern concept of relaxation, a core component underpinning the clinical conception of mindfulness (48,163–165).

In the current study, evidence often trended in opposition to our main hypothesis, showing an increase in scores in the world group, suggesting we may well have undervalued the effects off world-focused meditation. Note however that, although not a sensitive trend, participants themselves expected the world condition to provide greater benefits to mental health than the mental states condition, and viewed this practice as more ‘authentic.’ Other studies have shown people tend to assume that attending to negative affect will be distressing (78), and this may have affected participant’s view of the Mental States intervention. Expectations and perceptions of authenticity are key drivers of placebo effects, and this might bias outcome scores towards the World group.

If Mindfulness of the World were regularly shown superior to Mindfulness of Mental States in a head-to-head comparison, order effects should then be considered. Many Buddhist scriptures often suggest that body and world-focused practice are a necessary cleanser for deeper metacognitive insight meditation to take place (166, pp.15-17). Certainly, calm states are easier to distance from than intense ones, but in calming the mind on the body and externalities one learns the techniques of mindful observation on a less personal stimulus before turning this perspective inwards. Perhaps then, practitioners are best introduced to the shallow end of the mindfulness pool – an approach likely employed by many therapists of other traditions, where change can be expected to be gradual and laborious. As we suggest above, the mindfulness of mental states intervention may simply have been too difficult for novice meditators.

**Mental Health**

Mental health is the main outcome by which mindfulness is often assessed. We record sensitive increases in each of our scale measures in the world group over the waitlist group, and in the mental states group in measures of depression (PHQ-8) and rumination (RRS). Anxiety (GAD-7) and Thought Suppression (WBSI) recorded evidence to the null for the comparison between our interventions, with means trending in the direction of an increase in the World group. Only the PHQ-8 measure of depression recorded an effect sensitively in line with our hypothesis of superiority of the mental states group over the world group. Note, however, that evidence disappeared into insensitivity for these comparisons in the per-protocol data, outside of higher scores in the Mental States group over Waitlist on the PHQ-8, and the World group over Waitlist on the RRS. We thus find some preliminary evidence, on only one scale, for the existence of unique benefits of Mindfulness of Mental States. Notably evidence trended in the other direction for the sister scale of the PHQ-8, the GAD-7, a measure of anxiety. This trend suggests this pairing of scales could reveal differential specific effects of these interventions, and thus distinct mechanisms underlying their target disorders, in future replications.

**Conclusion**

This paper attempts to construct an active yet inert mindfulness control intervention in order to test claims that the therapeutic benefits of mindfulness are merely a reflection of socio-cultural properties of the practice. Despite a relatively large sample size, data were largely inadequate to test this theory, although current evidence is against the theory that Mindfulness of Mental States is a superior intervention to Mindfulness of the World. Therefore, the placebo effect may account entirely for the effects of mindfulness. On the other hand, one might presume a world-focused mindfulness to have its own specific effects which function as a precursor to effective metacognitive mindfulness practice. Ultimately, interpretations of this paper rely on the reader’s opinion of our definition and operationalisation of mindfulness.

# Disclosures

**Acknowledgments**

Data collection for the pilot study was partly completed by Freya Goninon, Olivia Lim, Sally McKean, Elena Allica, Ellen Harding, Gail Butler, Megan Palmer, Harriet Alabaster, Edan Collet, Fabio Mannino, Ellen Jones, and Izzy Bros.

**Ethical Statement**

Ethical approval for the main study has been received from the University of Sussex ethical committee (ER/MEL29/7).

**Funding Statement**

Zoltan Dienes was partially funded by grant 163/18 from the BIAL foundation and grant ES/P009522/1 from the Economic and Social Research Council.

**Data Accessibility**

All data and code used in this project are freely available in the online supplementary and following GitHub repository: <https://github.com/Max-Lovell/MindfulnessOfMentalStates> (DOI: 10.5281/zenodo.4390462; [167]) and at this OSF repository: <https://osf.io/vu2dk/files/>.

**Competing Interests**

We have no competing interests.

**Authors' Contributions**  
Author’s contributions: Pilot data was collected by several undergraduate and master’s students for final projects over several years (see Acknowledgements, above; ML also helped collect pilot data on his MSc). ML wrote the code for the materials and analysis, drafted the manuscript, and contributed to design changes for the main study. ZD conceived of the study, designed the pilot and co-designed the main study, participated in pilot data collection, and provided feedback on the manuscript. This project is in contribution to ML’s PhD thesis, with ZD as supervisor. Both authors gave final approval for publication and agree to be held accountable for the work performed therein.

# Hypothesis registration table

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Question** | **Hypothesis** | **Sampling plan** | **Analysis Plan** | **Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis** | **Interpretation given different possible outcomes** | **Theory that could be shown wrong by the outcomes** |
| Do expectations to improve account for difference in outcomes? | Mindfulness of Mental States and Mindfulness of the World will have ‘equivalent’ expectations for a change in mindfulness and for depression and anxiety. | Estimated 120 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | Separate analyses run for mindfulness and for depression/anxiety expectations. Bayes Factor of expectancy difference between Mental States and World group. As expectations should be limited to tracking outcome changes, H1 estimated at double the likely effect size (2x.2=.4) - and modelled as a normal distribution (M=.2,SD=.1) as larger, not smaller expectations likely to lead to larger outcomes. If expectations are non-equivalent but this difference is small, we will factor this out by adjusting the means for expectation effects. | *B* > 3 is the amount of evidence just worth taking note of, by tradition | *B* > 3, expectations non-equivalent, *B* < 1/3, expectations equivalent. | Any effects noticed in the mindfulness of mental states intervention are not due to the placebo effect. If expectations track outcome changes, the effect of the manipulation cannot be determined as separate from these expectation effects (manipulation check). |
| Did the time taken to complete the intervention affect the outcome obtained? (non-crucial) | Mindfulness of Mental States and Mindfulness of the World will take ‘equivalent’ amounts of time to complete. | Non-crucial test. | Bayes Factor difference in time taken between mental states and world group for using model of H1 with an SD of the raw difference in TMS scores between interventions divided by slope of regression of TMS on time taken to complete an intervention. | As above | *B* > 3, time taken non-equivalent, *B* < 1/3, time taken equivalent. | Any effect in outcome variables may be due to time taken to complete intervention (non-crucial manipulation check). |
| Has metacognitive task performance been equalised between conditions? | Mindfulness of Mental States will have ‘equivalent’ d’ scores to Mindfulness of the World. | Non-crucial test. | Bayes Factor of mean difference in d’ between groups, with H1 modelled as a half-normal with an SD of the difference in meta-d’ between groups | As above | *B* > 3, task performance non-equivalent, *B* < 1/3, task performance equivalent. | Any effect in meta-d’ may be due to task performance (non-crucial manipulation check). |
| Is mindfulness a metacognitive practice? | Mindfulness of Mental States will increase d’ adjusted meta-d’ scores over Mindfulness of the World. | Estimated 160 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | Bayes Factor of interaction contrast between mental states group and world group by pre vs post, using model of H1 with SD =.5 meta-d’ units difference. | As above | *B* > 3, metacognition training increases mindfulness. *B* < 1/3, the extra metacognitive training is not useful for a short mindfulness intervention in order to increase mindfulness. | Metacognitive mindfulness training enhances adjusted metacognitive sensitivity (manipulation check). |
| Does training in mindfulness of mental states rather than the world promote more mindfulness of mental states? | Mindfulness of Mental States will increase TMS-D (decentring) scores over Mindfulness of the World. | Estimated 220 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | Bayes Factor of interaction contrast between mental states group and world group by pre vs post, using model of H1 with SD =.2 Likert units difference. | As above | *B* > 3, metacognition training increases mindfulness. *B* < 1/3, the extra metacognitive training is not useful for a short mindfulness intervention in order to increase mindfulness. | Metacognitive mindfulness training enhances the facilitation of mindfulness of mental states in the short-term (manipulation check). |
| Does a metacognitive component of mindfulness account for its positive effects on mental health, specifically in reducing depression? | Mindfulness of Mental States will decrease PHQ-8 (depression), scores over Mindfulness of the World. | Estimated 180 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | As above | As above | *B* > 3, metacognitive training is an important component of the effectiveness of mindfulness on depression in the short term. *B* < 1/3, metacognitive training is not an important component of short-term mindfulness interventions on depression. | Metacognitive training is key to the beneficial effects of short-term mindfulness interventions on depression. |
| Does a metacognitive component of mindfulness account for its positive effects on mental health, specifically in reducing anxiety? | Mindfulness of Mental States will decrease GAD-7 (anxiety), scores over Mindfulness of the World. | Estimated 220 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | As above | As above | *B* > 3, metacognitive training is an important component of the effectiveness of mindfulness on mental health in the short term. *B* < 1/3, metacognitive training is not an important component of short-term mindfulness interventions on anxiety. | Metacognitive training is key to the beneficial effects of short-term mindfulness interventions on anxiety. |
| Is the Mindfulness of the World an effective mindfulness intervention? | TMS-D scores will increase in The Mindfulness of the World group over Waitlist controls | Estimated 180 participants needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | As above, except between World and Waitlist Group | As above | *B* > 3, Mindfulness of the World training increases mindfulness (TMS-D) scores, *B* < 1/3, the Mindfulness of the World group was not successful in increasing mindfulness scores. | Mindfulness of the world is an effective part of mindfulness training that can be targeted (manipulation check). |
| Mindfulness of the world has positive effects on mental health, specifically in reducing depression | Mindfulness of the World will decrease, and PHQ-8 (depression) scores compared to the Waitlist control. | Estimated 150 participants for PHQ-8 needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | As above | As above | *B* > 3, mindfulness of the world is an important component of the effectiveness of mindfulness on depression in the short term. *B* < 1/3, mindfulness of the world is not an important component of short-term mindfulness interventions on depression. | Mindfulness of the world is a component of the beneficial effects of short-term mindfulness interventions on depression. |
| Mindfulness of the world has positive effects on mental health, specifically in reducing anxiety | Mindfulness of the World will decrease, and GAD-7 (anxiety) scores compared to the Waitlist control. | Estimated 180 participants for GAD-7 needed. Sample until one of: i) *B* > 3; ii) *B* < 1/3; or iii) N = 300 | As above | As above | *B* > 3, mindfulness of the world is an important component of the effectiveness of mindfulness on mental health in the short term. *B* < 1/3, mindfulness of the world is not an important component of short-term mindfulness interventions on anxiety. | Mindfulness of the world is a component of the beneficial effects of short-term mindfulness interventions on anxiety. |

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1. Pre-approved changes to procedure from stage one comprise: 1) a 10 rather than 14 day intervention, 2) automation of emails, 3) the sending of a post-test reminder email after drop-out 4) asking participants to resize a box to the size of a credit card in order to determine pixel-to-cm ratio. Approval for these changes was granted via email 08 March 2022. Several unregistered changes to the protocol were also made, comprising: 1) Using an induction text rather than audio session 2) Switching materials from jsPsych to vanilla JavaScript 3) running Hmeta-d through R rather than MATLAB. [↑](#footnote-ref-2)